Fermilab
PPD/MD/Engineering Analysis Group

The Effect of Friction Force for a 40 Planes Block (TASD geometry) __ 3

Ang Lee
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Introduction

This is an extension of the earlier study related to the filling process study. The 40 planes model starts its first 4 extrusions filling, and a solution is obtained. Next 4 extrusions will be filled under a previously deformed geometry and second calculation is performed and so on. It is a nonlinear analysis in which the stiffness matrix will be updated during iterations to fact in the deformed geometry. The frictional coefficient is assumed to be 0.3 cross the bottom. The X is defined as the beam direction. Y is the vertical axis and Z is in its width direction. The result is summarized as following:

1) **Fig. 1:** The displacement along beam direction (X) after 40 planes filled.
2) **Fig. 2:** The deformed structure at last vertical extrusion verses its height (Y). It peaks around 40" from the bottom and then comes back to the zero at the top due to the zero pressure. The relative displacement is still around 60 mils for the case of the 40 planes filled.
3) **Fig. 3:** The displacement along beam direction at the bottom (Y=0).
4) **Fig. 4:** The displacement along the beam direction at Y=40.39" (from the bottom).
5) **Fig. 5:** The stress result for the case of after 4 planes and 40 planes filled.

Discussions

With a nonlinear model (a stiffness matrix updated during the iteration), the relative displacement within 40" from bottom still remains around 60 mils for a frictional coefficient=0.3 (Fig 1 & 2) after 40 planes have been filled. It is very much the same as one observed in a linear model[(1)]. This ~60 mils is accumulated from the expansion of 40 extrusions under 21 psi. The bottom of structure does not move much due to its friction. Therefore, a relative displacement is created within the extrusion. It results an additional stress. The stress plot shows that the max stress is changed from 600 psi for a 4 extrusions filled to 1,000 psi for a 40 extrusions filled. If a full detector with 2000 planes is built without any periodic gaps or intermittent stops to cut off this accumulative displacement, this stress could be built up rather quickly, and it will even exceed the operating stress. By having several gaps, however, along the beam direction, this complication could be minimized and may also have some positive effect for the relief of the thermal expansion.

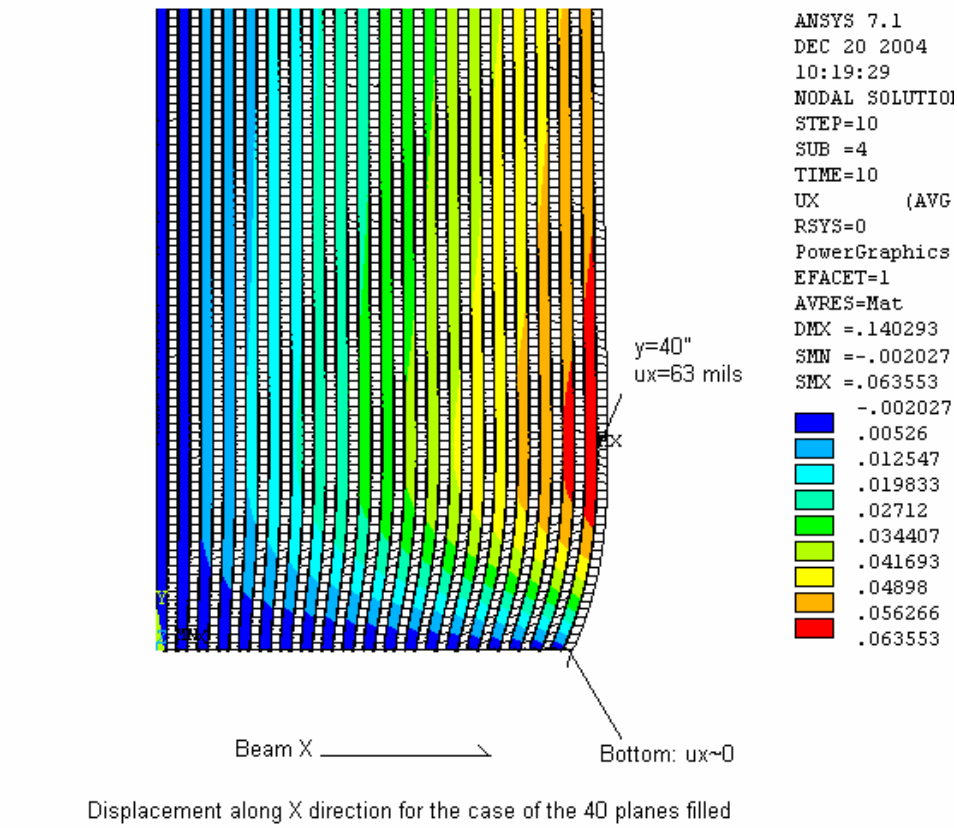

Fig. 1 The displacement along the beam direction after 40 planes filled

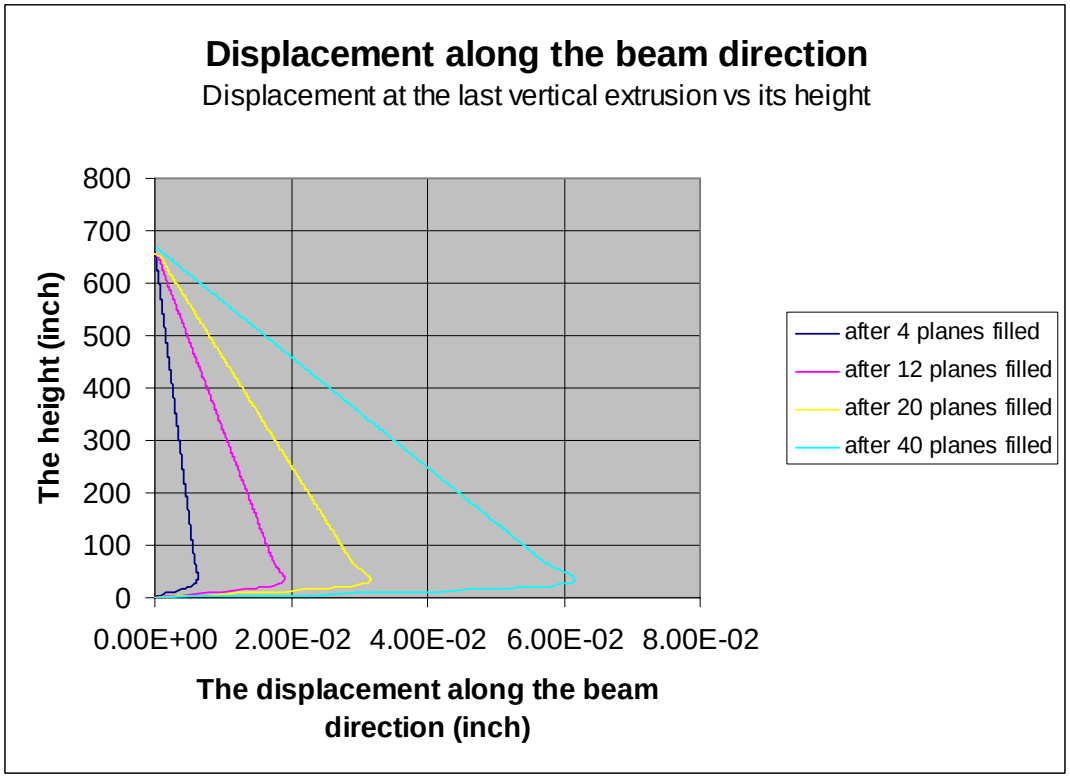

Fig. 2 The deformed structure shape vs its height at last vertical extrusion

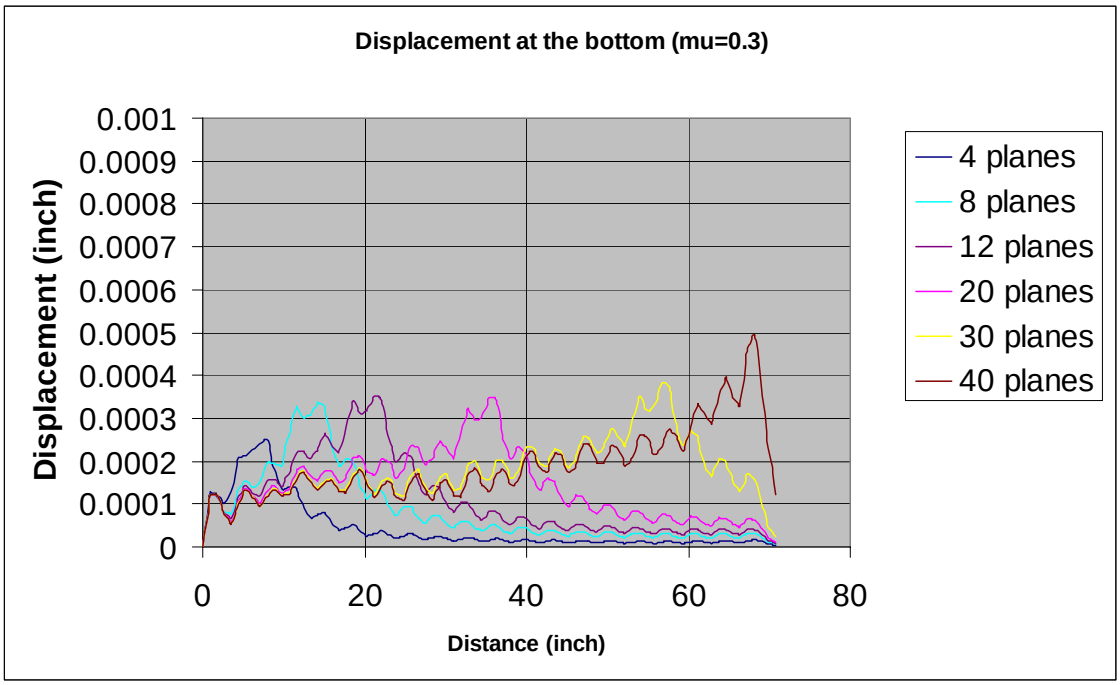

Fig. 3 The displacement at the bottom of the extrusion

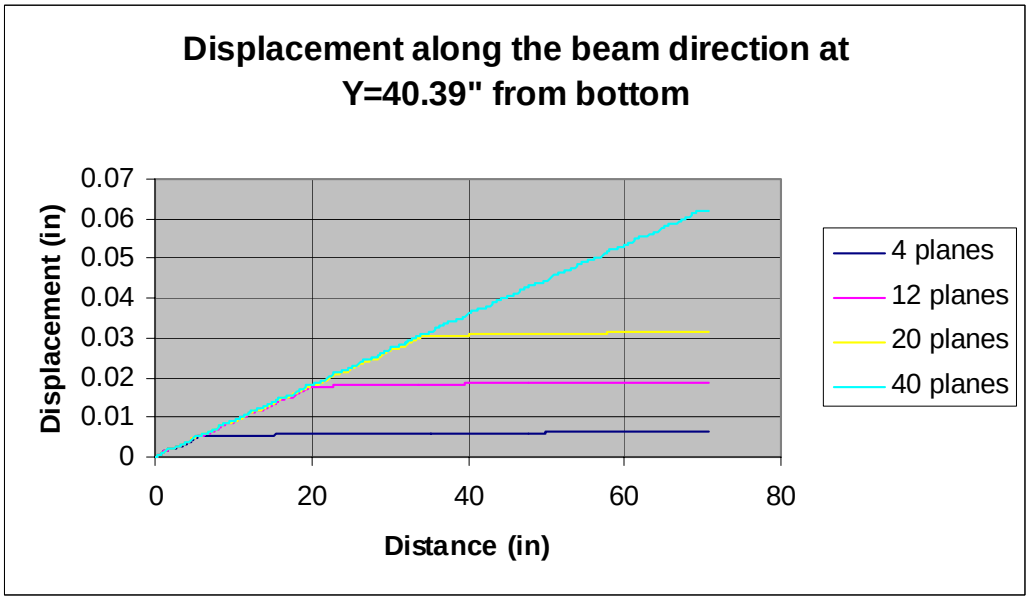

Fig. 4 The displacement along the beam direction at Y=40.39”

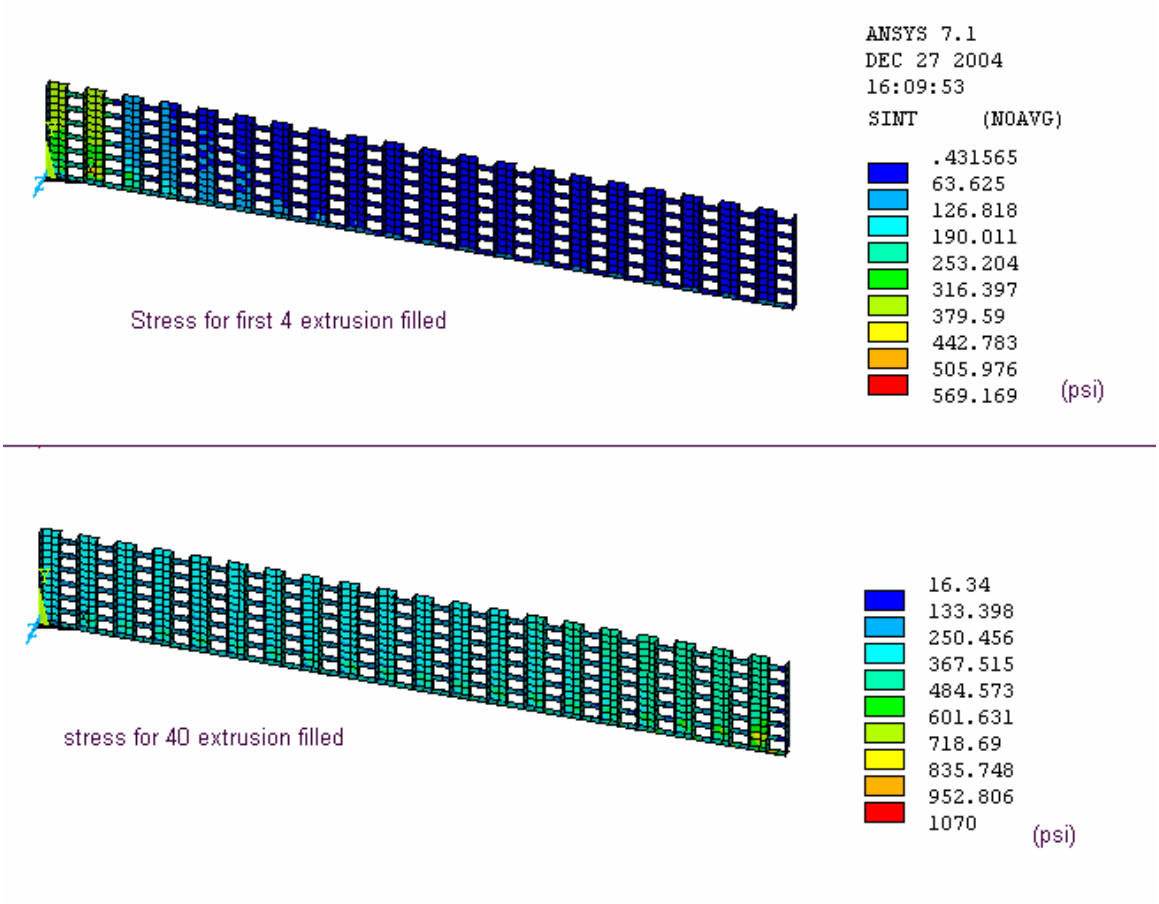

Fig. 5 The stress for both 4 extrusions filled and 40 extrusions filled

Reference:

1)Ang Lee: "The effect of Friction Force for a 40 planes Block (TASD geometry)__2", Nov 29, 2004

Appendix:

The ANSYS Model details:

The model uses a slice of the structure in the mid of section. It has one-half of single cell size along width direction Z(0.748"), a full height along Y (17.5 m) and 40 planes along the beam direction X. The plate element is used with a mesh size around 1". It results 125,800 elements and 109,734 nodes for this particular model. The contact region is simulated by the contact173 and target170 for a surface contact with mu =0.3 specified. The large deflection and geometry nonlinearity is on to fact in the deformed geometry. The symmetry boundary is imposed for both Z=0 and Z=0.748". A symmetry constrain is also imposed at X=0 as shown in Fig 6. The model initially has a density to account for an empty extrusion weight only. Then, 21 psi pressure (surface load) is linearly distributed from bottom to top for the side wall of the vertical extrusion only. The weight of the mineral oil is treated as a nodal force applied uniformly for both vertical and horizontal extrusions. The reaction force from the ANSYS has been checked with a hand calculation to make sure that the model has been properly loaded. For first 4 extrusions loaded, the total weight will be

36 *30000*15% +4*30000=282000 lb (for a full size 17.5 m x 17.5 m x 40 planes)

For one-half of the single cell width, it will be 282000/(14*32)/2=314.73 lb/half cell. Ansys model gives 315 lb total reaction force for first load step (4 extrusion filled). It is consistent with the hand calculation above. The solution file has total 10 load steps. Each load step has 4 extrusions loaded.

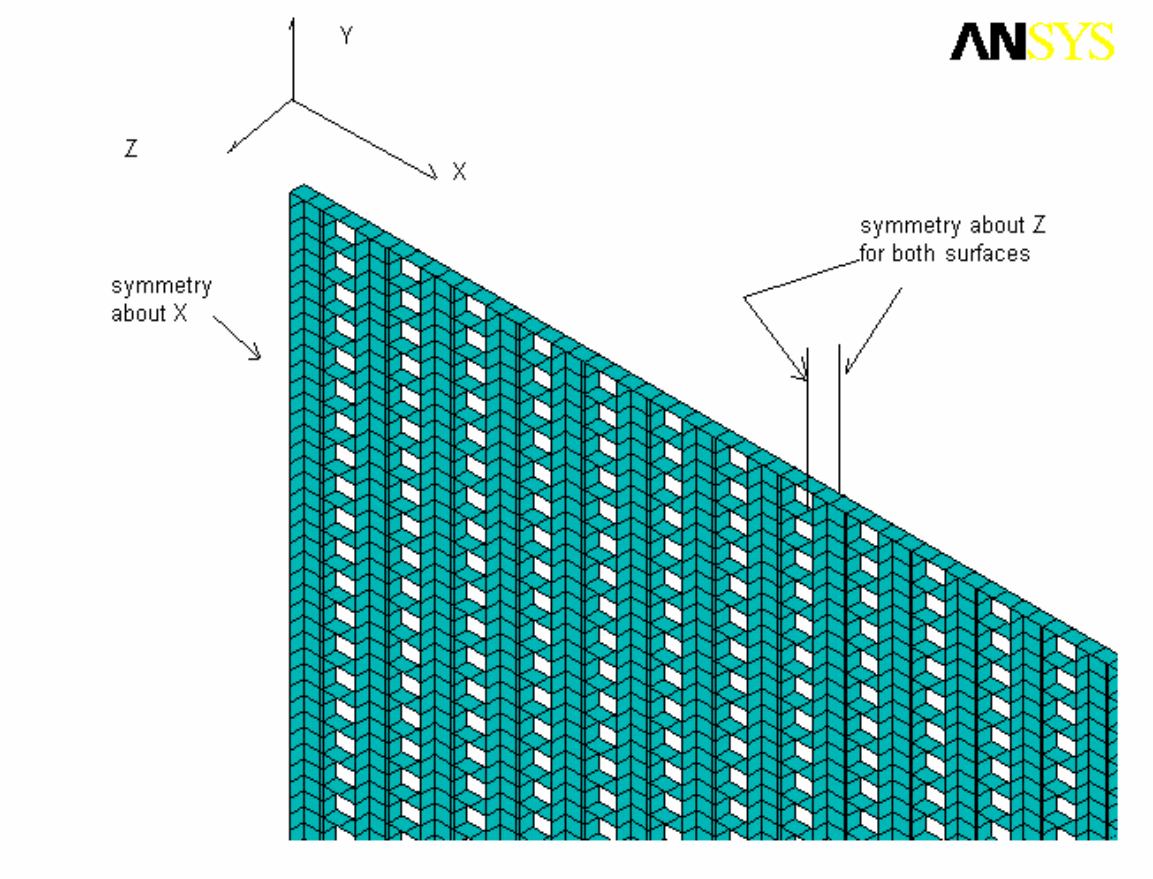

Fig 6 The FEA model details